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New Glass Design Approaches Developed During an Experimental Student Workshop

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During two semesters the ILEK (Institute for Lightweight Structures and Conceptual Design) held an explorative student workshop focusing on new glass design possibilities. Students from the faculties of Civil Engineering and Architecture first gained insight into the theoretical foundations of glass and different fabrication techniques, and then applied these techniques to realize a design theme of their choosing. The range of themes was intentionally left open and the scope of the techniques employed was correspondingly broad. For example, flexible glass-hybrids, pure glass-glass joints and three dimensionally deformed glass panes were created, the haptic variation of fused glass shards was studied, and pre-deformed glass stripes fused together to generate woven glass. The objects evolved were not intended for direct incorporation into architectural applications, but rather as a stimulus for new glass design ideas beyond the aspect of transparency. This paper presents a detailed description of the various objects and the techniques employed.

Keywords: Glass Design, Workshop, Experimental

1. Introduction

At the ILEK (Institute for Lightweight Structures and Conceptual Design) an experimental teaching approach has been employed for the past several semesters. Instead of introducing only the theoretical principles and properties of materials to the students, the students have been given the opportunity to experiment themselves with various materials and to try to broaden the scope of their application. In the summer semester of 2008 and the winter semester of 2009 the students dealt with the material glass. After learning the fundamental material properties and the basic material processing techniques, each student carried out an explorative study following a self-chosen theme. A variety of models were created with the aim of enhancing both the structural and the architectural qualities of glass – ideally simultaneously. The workshop can be thought of as a bridge between teaching and research, giving a glimpse of new and innovative glass design possibilities.

2. Description of the objects

While glass is seeing more and more use in contemporary architecture, it is almost always employed as a plane element. The aim of two students was to three-dimensionally deform glass panes using thermal treatment. Within a temperature range of 650-750°C the stiffness of glass is greatly reduced and the glass pane deforms between defined fixed points – this technique is called slumping. Simple materials like rounded stones, sharp nails and metal rods were used to define highpoints or ridge lines. Different curvatures of the glass pane could be achieved at different temperatures. A detailed study was performed to determine the optimal temperature range, thermal exposure duration and the best highpoint positioning pattern to achieve a desired shape. Through the three-dimensional deformation process, the geometric stiffness of the original plane glass element can be increased, and at the same time a unique visual appearance can be achieved. This may result in an improvement of the structural and architectural characteristics simultaneously. In this case the objects created also recall the design vocabulary of textile lightweight structures.

Figure 1: Pointly supported and deformed glass pane.

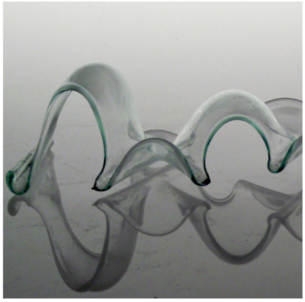

Figure 2: Linearly supported and deformed glass pane.

The creation of continuous glass elements out of broken glass shards by thermally fusing them was studied in another project. A sequence of experiments was carried out using everything from regular float glass to thermally strengthened glass, from randomly arranged glass shards to intentionally laid configurations, from short to long thermal exposure durations, and from colourless to colourful glass. A manifold of shapes with diverse haptic qualities was created varying from sharp-edged and fragile to smooth-edged and sturdy glass agglomerates. Compared to regular plane glass panes a controlled diffusion of light is achieved, while the appearance of colourless glass is maintained.

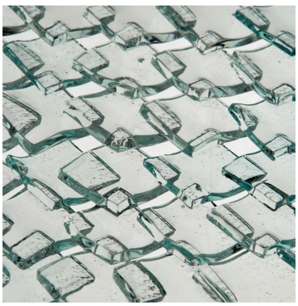

Figure 3: Fused glass shards – regular arrangement, short heat exposure.

Figure 4: Fused glass shards – irregular arrangement, long heat exposure.

Two students began with the vision of realizing pure glass-glass joints. To join glass elements, typically bolted or clamped connections are used. Glued connections with silicone have recently seen broader use, and connections using acrylate glues have been the topic of several recent research initiatives. But with all of these connection techniques at least one other material is introduced, and especially around elements such as drilled holes, significant stress concentrations arise. To avoid these issues and to generate clean, pure glass joints, the students first tried to melt the glass elements together by positioning them in an oven and subjecting them to temperatures of around 750 °C. But since the heat was evenly distributed in the oven, the glass also deformed in areas which were supposed to remain undeformed. Eventually, a technique was applied which is frequently used in the manufacturing of glass instruments – the joining of Borosilicate glass through local heat application. While Soda-lime glass breaks when locally heated due to temperature-induced stress concentrations, Borosilicate glass has a significantly lower coefficient of thermal expansion ($\alpha_{T,\,Borosilicate} = 3.3x10^{-6}$ 1/K; $\alpha_{T,\,Soda\text{-}lime} = 9x10^{-6}$ 1/K) and is therefore much more resistant to temperature shock. At the laboratory for physical and chemical instruments at the University of Stuttgart one student bent and joined Borosilicate glass rods using local heating to create a three-dimensional glass structure with pure glass-glass joints; while the other student connected planar glass elements in a linear welded joint. To reduce the internal stress in the glass, the planar elements were placed in an over and preheated to 500 °C before a flame treatment was applied within the oven space to create the weld.

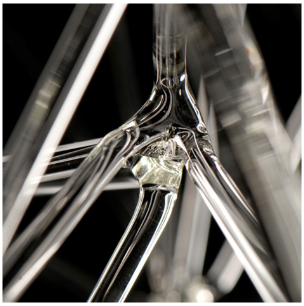

Figure 5: Glass-glass joint.

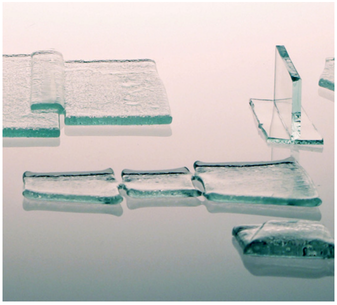

Figure 6: Linear welding study models.

Another student investigated the idea of combining the fundamentally different material characteristics of glass and textiles with the aim of creating a flexible glass hybrid material. In a study, glass platelets, or sequins, were fused onto different wire filament meshes at high temperatures (around 800°C). Numerous studies were necessary to determine the best temperature range to completely embed the filaments but prevent the glass sequins from bleeding together. Unfortunately, most of the wire filaments lost their flexibility during this heat treatment and became very brittle. A durable flexibility was only achieved with a thin multifilament steel yarn. During this series of experiments an unexpected effect occurred: the coating of a silver-coated copper wire was burnt onto the underlying oven stones. When a glass pane lying on the residual silver-coating was later subjected to a heat treatment, parts of the residual silver coating fused to the glass pane, resulting in bi-coloured light effects depending on whether light was being reflected from or transmitted through the pane. A printing process for local dichroic coating was inadvertently discovered.

Another student wanted to translate the visual appearance of textiles to glass. While the fabric warp thread – due to its inherent flexibility – bends easily around the weft threads, multiple steps had to be carried out with glass stripes until a similar appearance was achieved. First, flat glass stripes were thermally deformed to create warp stripes. These stripes were then placed next to each other, but with alternating high and low points. Into this arrangement flat weft stripes were inserted. Ultimately, everything was placed in the oven again and melted together at around 730 °C and finally, a woven glass object was obtained.

Figure 7: Flexible glass hybrid.

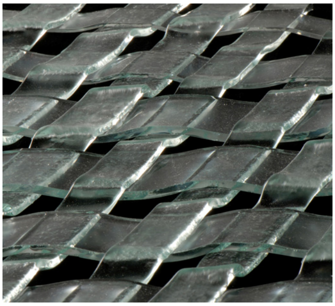

Figure 8: Woven glass.

3. Summary

Through this experimental teaching method the students gain fundamental knowledge of glass as a material, and work following their own research initiatives. They are free to experiment with the material, exercise their creativity, and make their own discoveries. The objects created are not intended for direct architectural application, but rather to serve as stimulus for a new and innovative design approach for glass elements.

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